RESILIENT POWER
A project of Clean Energy Group

Resilient Power in Practice: Lessons Learned from the Field

June 27, 2018

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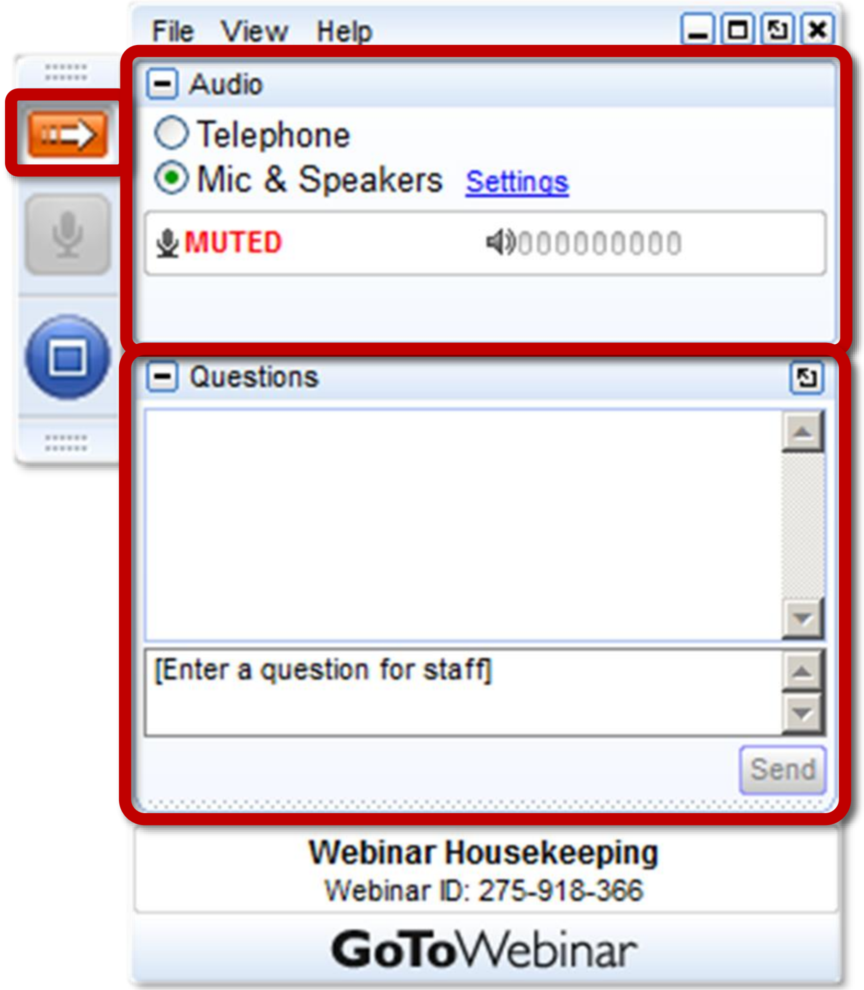
HOUSEKEEPING



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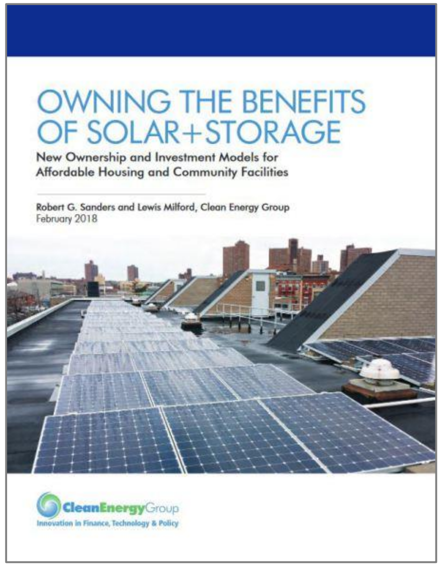
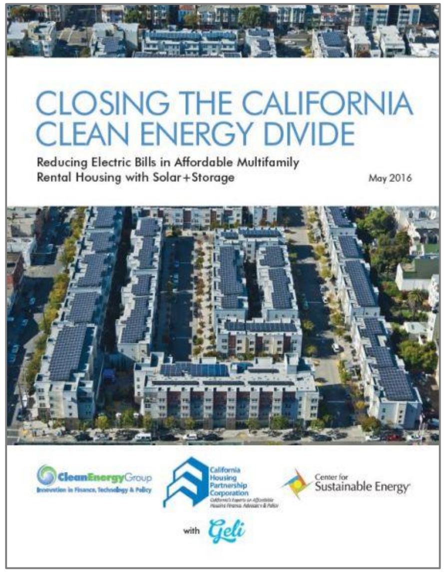
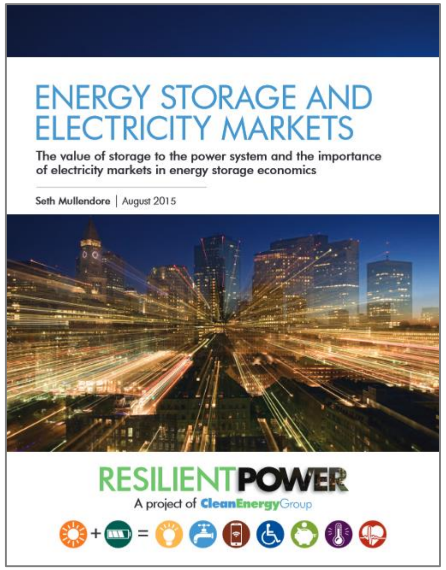
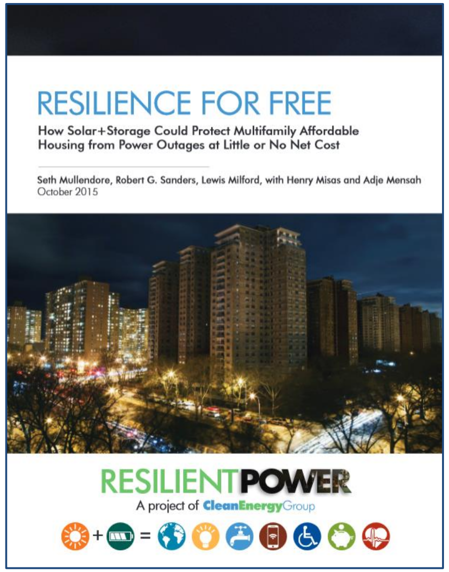
THE RESILIENT POWER PROJECT

- Increase public/private investment in clean, resilient power systems (solar+storage)
- Protect low-income and vulnerable communities, with a focus on affordable housing and critical public facilities
- Engage city, state and federal policy makers to develop supportive policies and programs

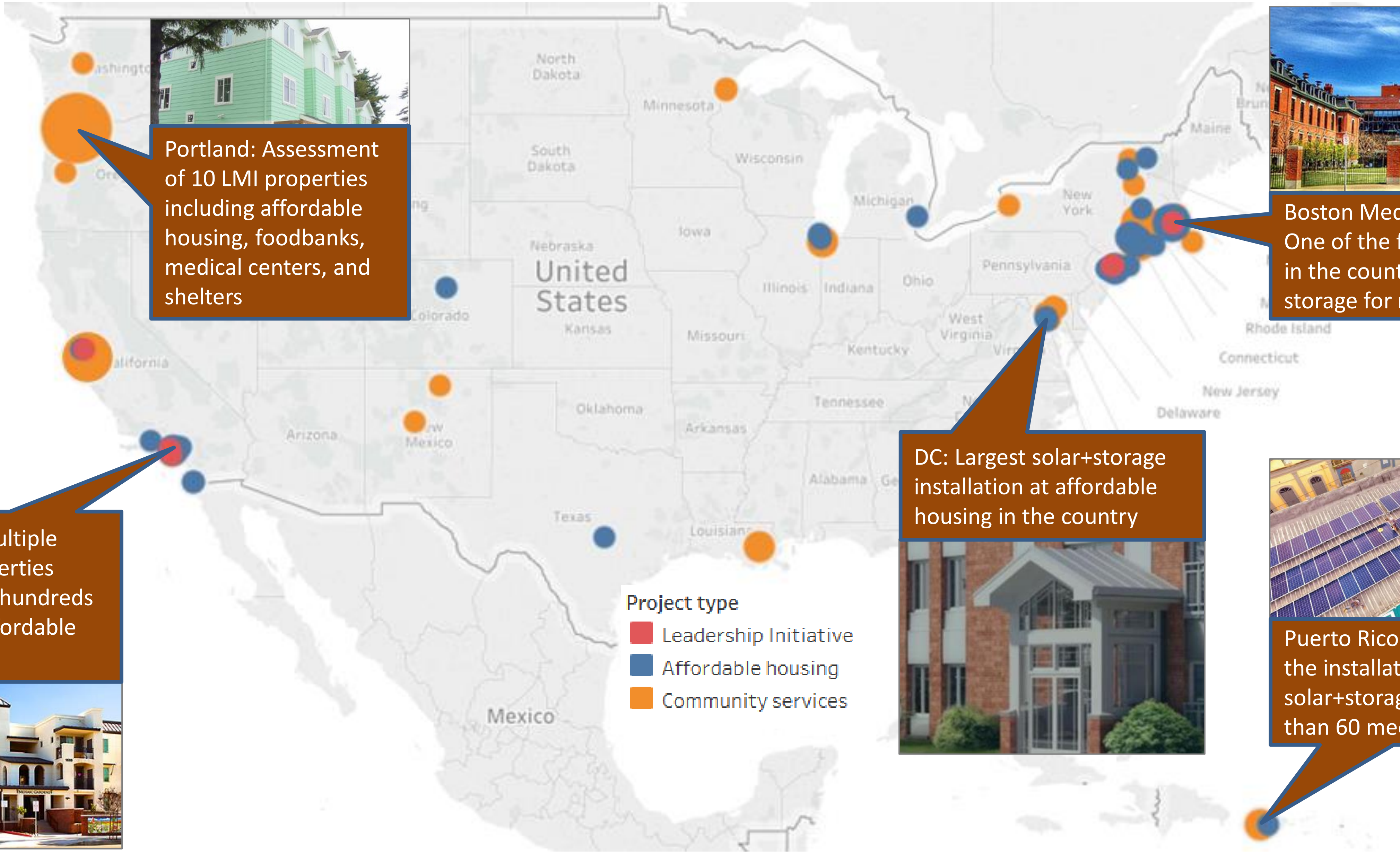








SUPPORTING 100+ PROJECTS ACROSS THE COUNTRY



Portland: Assessment of 10 LMI properties including affordable housing, foodbanks, medical centers, and shelters

Boston Medical Center: One of the first hospitals in the country to install storage for resiliency

California: Multiple housing properties representing hundreds of units of affordable housing

DC: Largest solar+storage installation at affordable housing in the country

Puerto Rico: Supporting the installation of solar+storage at more than 60 medical clinics

Resilient Power in Practice: Lessons Learned from the Field

Webinar Speakers

Dr. Travis Simpkins
Chief Technology Officer
muGrid Analytics

Geoff Oxnam
Chief Executive Officer
American Microgrid Solutions

Seth Mullendore
Vice President & Project Director
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muGrid Analytics

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Resilient Power in Practice: Lessons Learned From the Field

June 27, 2018

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Overview

- What is Resilient Power?
- Modeling Resilient Power Solutions
- Resilient Power Implementation
- Five Lessons from the Field
- Questions & Answers

What is Resilient Power?

Travis Simpkins, PhD

What Is Resilient Power?

"Resilient power is the ability not only to provide critical power to essential facilities and services during a power outage, but also to provide economic benefits throughout the year, by reducing power bills and generating revenue through providing services to utilities and grid operators."

-- Clean Energy Group

Resilient power = Having access to power when the grid goes down and making money when the grid is up.

It's not that simple…

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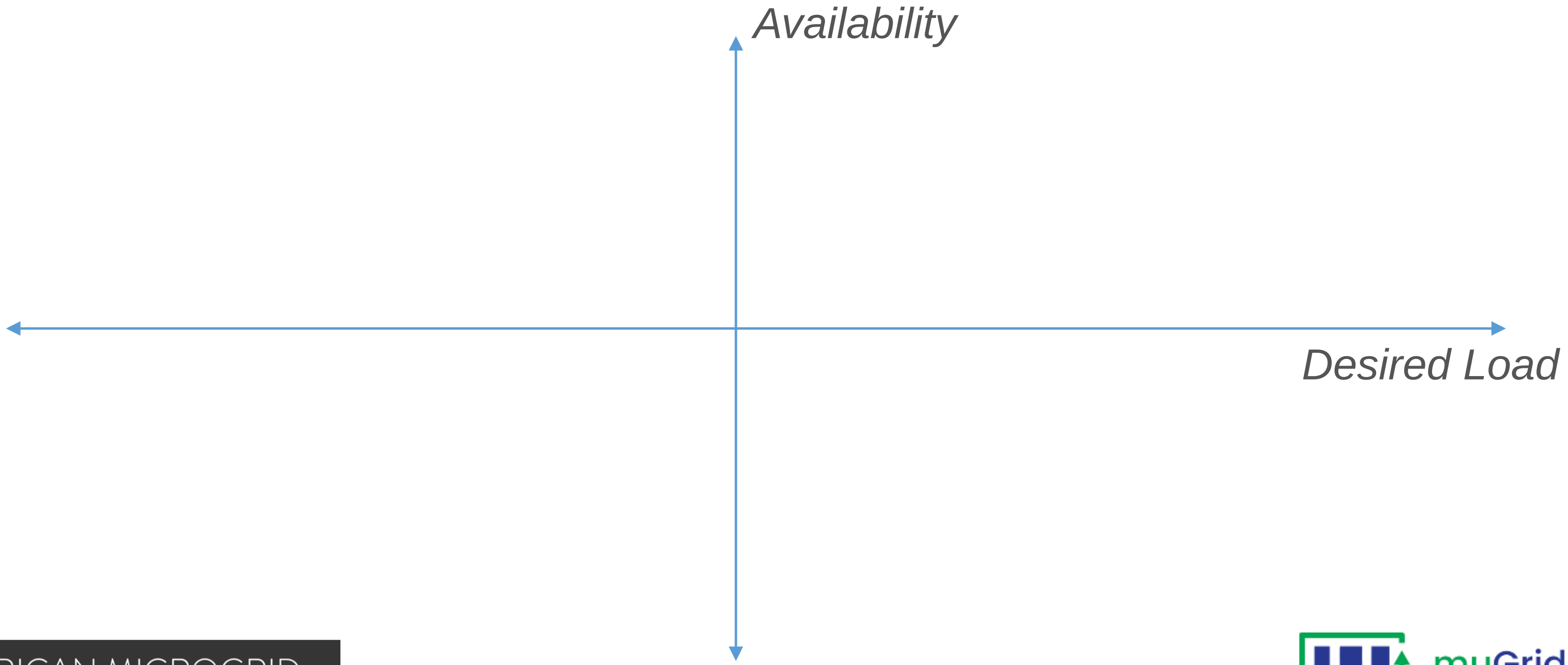
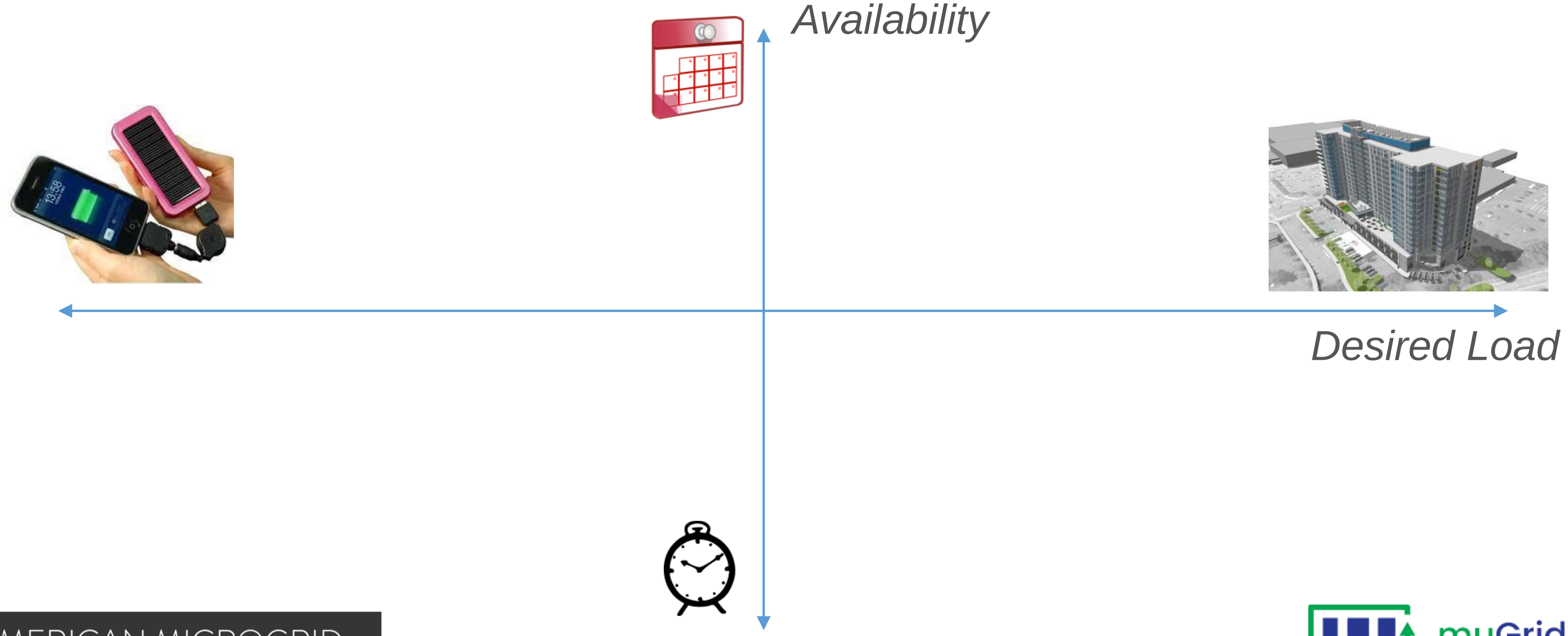
The Resilient Power Spectrum



The Resilient Power Spectrum



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The Resilient Power Spectrum

Availability

Desired Load

Load + Availability During Outage = Resilient Power

Like it or not, the definition of Resilient Power is SUBJECTIVE

Quantifying Resilience

- Energy resilience is ***probabilistic,*** and a function of many variables

Factors	Impacted by
Critical load	Season, weather, time of day
Solar radiation	Season, weather, time of day
Battery state of charge	Time of day, other applications being served
Amount of fuel on site	Size of tank or access to pipeline

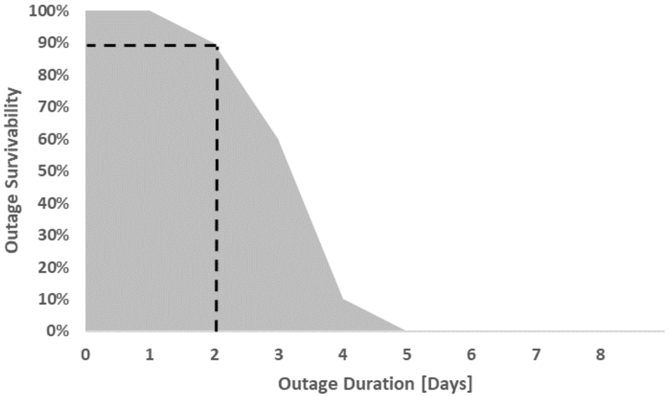
- Stochastic modeling and simulation is necessary to assess resiliency benefits

Modeling Resilient Power Solutions

Travis Simpkins, PhD

Resilience Requires Stochastic Thinking

- No backup power system is 100% reliable
  - Generators may not start
  - Diesel fuel tank might be empty, contaminated, or simply run out
  - Fuel lines can freeze
  - Natural gas pipeline could get damaged
  - Sun might not shine



- We should instead talk about probabilities and confidence levels
  - "We have a 95% chance of powering our critical loads for an outage lasting 3 hours and a 60% chance of 3 days, no matter when it happens during the year"
  - How much are we willing to pay to go from 95% to 99%? Or from 99% to 99.99%?

Resilience From Solar + Storage

- Most solar + storage systems being installed today are optimized for economics
  - Desire to use entire battery capacity for peak shaving
- But outages are probabilistic…
  - What if outage occurs when battery is at 0% SOC?
- Solutions:
  - Predictive: Ensure battery is charged before potential outage events
  - Reserve some of the battery for backup
  - Oversize the battery

Same

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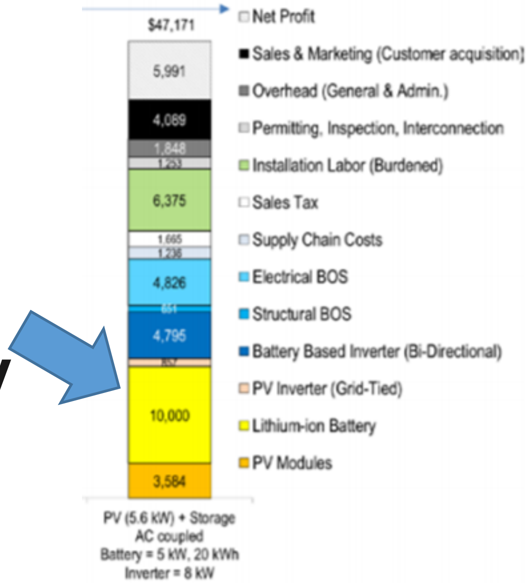
Strategy 1: Predict Outages

- Most <u>major</u> storms are predicted with good accuracy hours, and sometimes days, before they occur
  - Hurricane Sandy, Katrina, etc. etc.
  - Opportunity to charge the battery, either from the grid or from solar
- However, *minor* thunderstorms hit the east coast once a week in the summer
  - Deciding to stop peak shaving for even one day probably means that there was no point in peak shaving during that entire month
  - If there is a look-back, not peak shaving during one day could impact your savings for the entire next year
- So when do you decide to stop peak shaving?
  - Only for a Category 3 or above hurricane?
  - A nor’easter?
  - A thunderstorm?

There is a tension between operating for economics and preparing for outages.

Strategy 2: Build a Bigger Battery

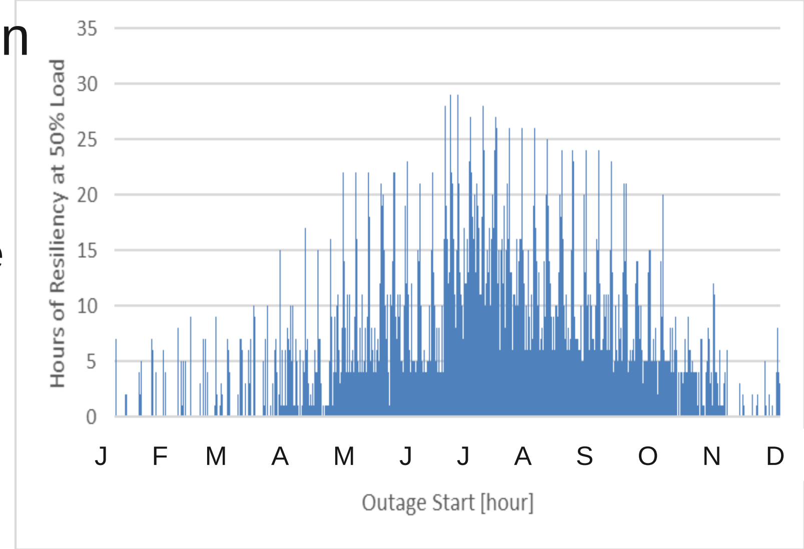
- There is an optimal amount of storage that maximizes the NPV / IRR for a given site based on peak shaving
  - Adding more storage reduces the economic return, because the incremental benefits from peak shaving are less than the incremental costs
- **But the incremental storage is some of the “cheapest” you can buy for resiliency**
  - Fixed costs are already included
  - Inverter costs are already included
  - Only new cost is for incremental battery modules to go from say 100 kWh to 200 kWh



National Renewable Energy Laboratory

Quantifying Resilience From Solar + Storage

- Objective: Determine number of hours that a solar + storage system can maintain critical load before failing
- Assumptions (aka "What does resilience mean to you?"):
  - Batteries are fully charged at start of outage
  - Critical load is always 50% of normal load
  - System fails *forever* when combination of solar + storage cannot meet critical load
- Repeat simulation for outages starting at every hour of the year



Amount of resilience available varies depending on time of outage.

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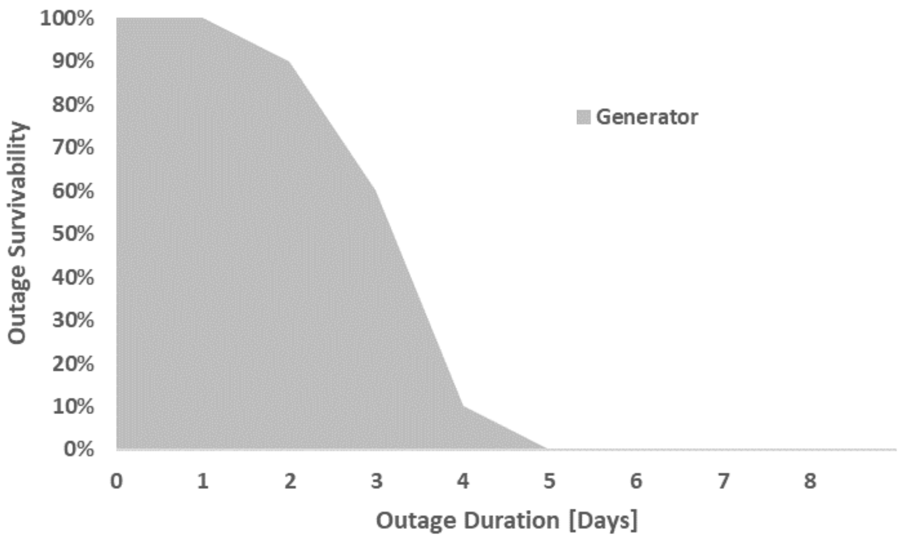
Resilience In Hybrid Systems

- Many facilities that value resiliency already have some form of backup generator
  - How can solar plus storage help improve their resilience?
- Conventional generators are only useful as long as they have fuel
  - Tank size is finite, often sized for “72-hours” of backup
  - Resupply may or may not happen
  - Pipeline operation is generally considered to be more reliable than the grid, but certainly not perfect
- Adding solar + storage to conventional generation can extend survivability

How Solar + Storage Increases Resilience



Survival Probability	Outage Duration [days]	
	Generator only	
100%	1	
60%	3	

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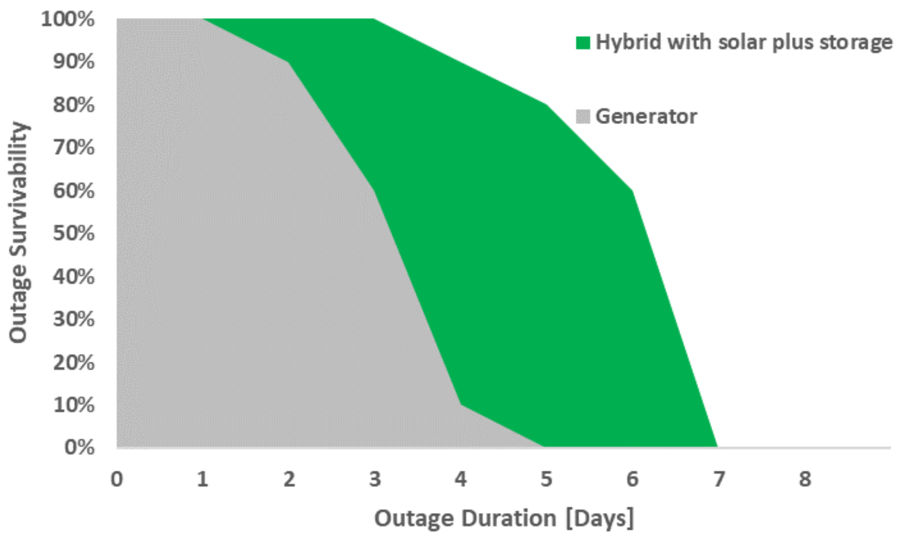
How Solar + Storage Increases Resilience



Survival Probability	Outage Duration [days]	
	Generator only	Hybrid with Solar + Storage
100%	1	3
60%	3	6

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Resilient Power Implementation

Geoff Oxnam

Resilient Power Component Considerations

- Generation: Understand the qualitative drivers in decisions
- Solar PV: Identify & communicate constructability early
- Storage: Focus on value then function
- Meters: Location and number are critical
- Operations: People are more important than equipment

Lessons from the Field

"Solar Ready & Resilience on the Go"
Community Centers, DC

"Virtual vs Reality in Microgrids"
Residential Campus, MA

"Big Things in Small Packages"
Neighborhood Resilience, MD

"Smart Cities Go Micro"
Smart City Municipal Campus, MD

"A Moving Playing Field"
Senior Living Facility, MA

"Timing is Everything"
Mixed-Use Re-Development, NY

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“Timing is Everything” - Mixed-Use Re-Development, NY

Goal: Integrate storage with planned solar on an innovative re-development during regulatory re-design

Challenge: Storage analysis while project underway and in evolving regulatory landscape

Takeaways

- Resilient Power projects have important community-wide impacts that create opportunities for leadership
- Quantify resilience goals & set your team early

"A Moving Playing Field" - Senior Living Facility, MA

Goal: Integrate storage into planned rooftop solar project

Challenge: Analyze feasibility in evolving regulatory environment

Takeaways

- Visionary organizations, and the champions within them, can unlock invaluable insights even when energy isn't their primary mission
- Time the analysis process to keep forward momentum even when information isn't perfect
- Keep your strategy flexible early and leverage the right goals

“Smart Cities Go Micro” - Municipal Government & Public Works Facility, MD

Goal: Develop a microgrid for municipal smart city project

Challenge: Deliver an effective Resilient Power solution working with a small staff, multiple project partners and evolving funding sources

Takeaways:

- Never be afraid to Think Big when it comes to reinventing a small community!
- Small projects with multiple funding sources create project management hurdles – be flexible and proactive

“Big Things in Small Packages” - Neighborhood Resilience, MD

- **Goal**: Develop Resilient Power solutions for community based organizations
- **Challenge**: Small, older buildings create unexpected constructability challenges

Takeaways

- Small facilities can play a huge role in resilience at the community scale
- Invest in collecting and field verifying data early

Solar Ready & Resilience on the Go – Resilient Community Centers, DC

Goal: Develop Resilient Power solutions for community centers

Challenge: Leverage multiple entities and program objectives

Takeaways

- Forward-looking policy and bright, motivated team players can drive Resilient Power solutions forward
- When budgets are tight, innovative design can create optionality, but phased solutions and retrofits are challenging

Virtual vs Reality in Microgrids" - Senior Living Campus, MA

Goal: Optimize Resilient Power resources in a residential campus into a microgrid

Challenge: Multiple buildings with multiple meters in close proximity and identical missions offer many solutions

Takeaways

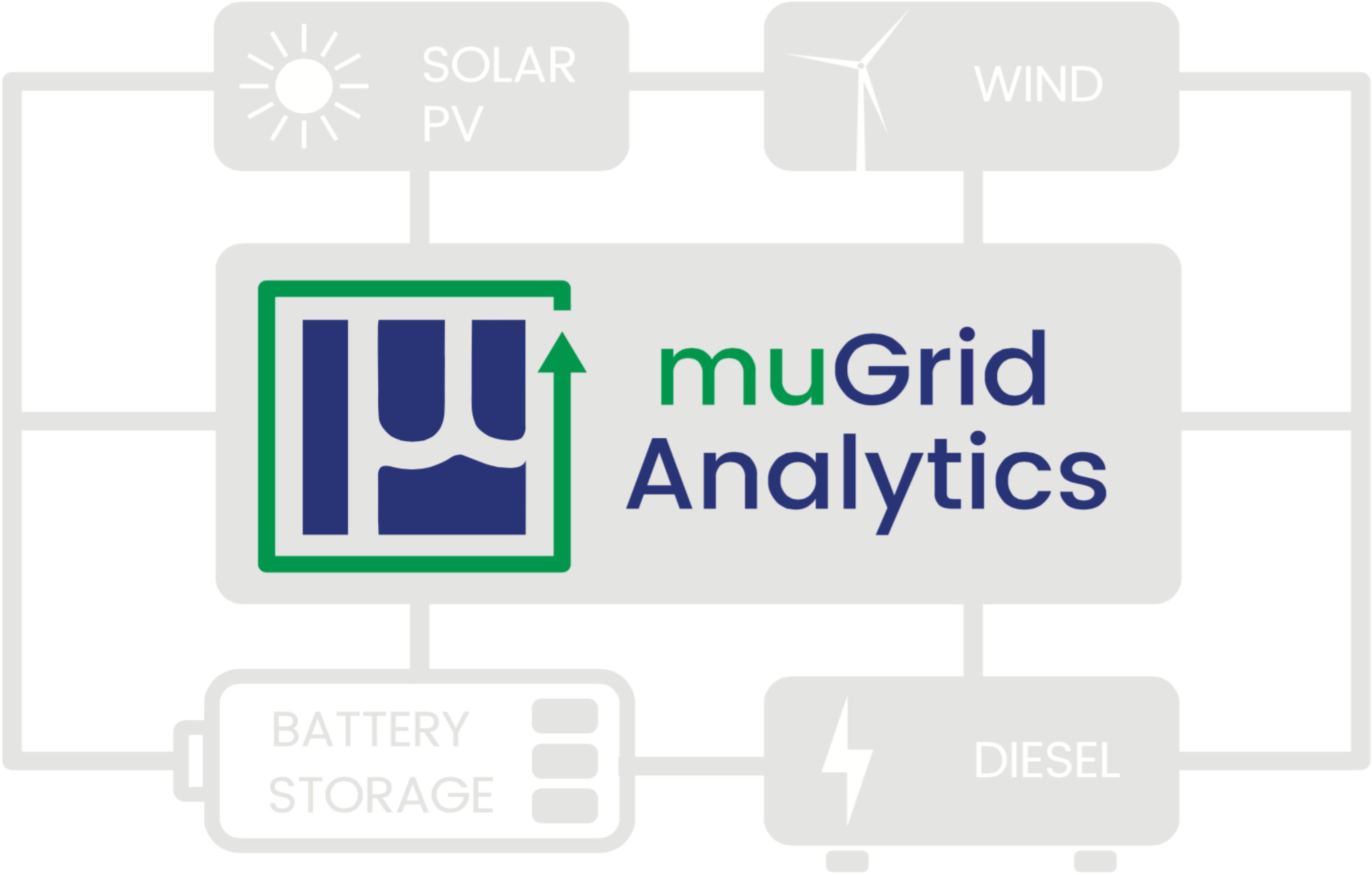
- Ownership structures are complex and create burdens for design
- Think about these from a functional perspective not always a physical perspective

5 Lessons From The Trenches

1. Commit to resilience early
2. Build the right team
3. Set clear goals
4. Assumptions & data matter
5. Operations improve economics

Questions & Answers

- Dr. Travis Simpkins, muGrid Analytics
- Geoff Oxnam, American Microgrid Solutions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Thank you for attending our webinar

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Replacing Peaker Plants with Battery Storage

Thursday, July 19, 2-3pm ET

Simplifying Resilient Power Design with REopt Lite: A Look at New Features Added to NREL's Solar+Storage Tool

Wednesday, July 25, 1-2pm ET

Building Markets: Energy Storage in Massachusetts and Offshore Wind in Rhode Island

Thursday, August 9, 1-2:30pm ET

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